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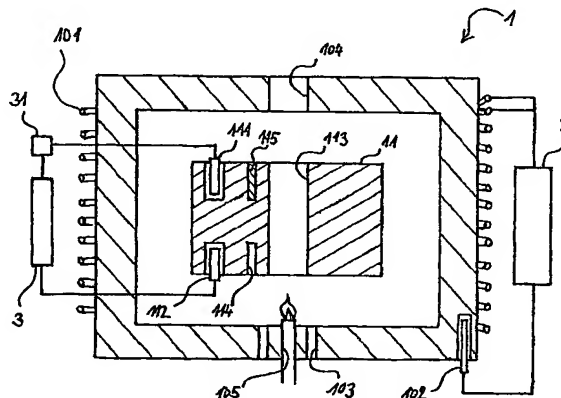
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(54) Title: APPARATUS AND METHOD FOR MEASURING THE HEATING OF GASES



(57) Abstract: The invention relates to a meter of the heating value of gases, consisting of an outer mantle with thermostatically controlled heating and with at least one inlet for air and the test gas, and of a measuring block placed inside the outer mantle, wherein the outer mantle (10) is cylindrical and equipped with the heating mantle (101) on the outside, its bottom part has an outer sensor (102) of the electrical long-distance thermometer of the outer thermostatic apparatus (2) placed axially in the wall, and simultaneously the measuring block (11) is cylindrical, with an axially directed through-hole (113), it is coaxially placed inside the outer mantle (10), its upper part contains the electrical heating block (111) inserted axially, its bottom part contains an axially placed internal sensor (112) of the electrical long-distance thermometer of the internal thermostatic apparatus (3), and the heating mantle (101) and the external sensor (102), and the electrical heating block (111) and the internal sensor (112) are interconnected via the thermostatic apparatus (2, 3), adapted for the maintaining of a constant temperature by regulation of the input to the heating mantle (101) to which the measuring apparatus (31) of the electrical input is also connected. Another principle of the invention consists in the method of operation of the meter, involving first the calibration stage, and subsequently the measuring stage takes place involving introduction and combustion of the test gas in the meter (1), with the measurement, by means of the measuring apparatus (31).



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## APPARATUS AND METHOD FOR MEASURING THE HEATING OF GASES

5    Technical Field

The invention relates to a measurement of the heat of combustion of gases, or the heating value of gases, especially it concerns meters for determination of the heat of combustion of heating gases whose heating capacity  
10    may vary during delivery to the customers, and thus continuous monitoring is required. The invention relates to a metering method, too.

Background Art

15

A great variety of instruments are used at the present time for measurement of the heat of combustion of gases. The so-called compensation meters that in principle compensate the differences in the heat of combustion of *the test gas through the heat produced in a compensation source* whose energy  
20    input is measured are often used for continuous measurement. In a number of these meters, an electrically heated block serves as the compensation source. In this case, the issue must be solved of attaining an equilibrium state between the input of heat from the compensation and test sources and the heat dissipation into the environment.       A possible solution to this problem is described in a patent  
25    CH 593484 where the test and compensation heat sources are placed in the meter block that is connected to the cooling block by means of a heat-conducting element and the heat gradient between the measuring and cooling blocks is maintained constant and measured. The outer mantle around the measuring block is a part of the thermal insulation preventing heat dissipation into the environment  
30    along pathways other than that via the heat-conducting element. Such a

measuring instrument is suitable for determining the heating capacity of a stable source placed in the measuring chamber but is less suited to continuous measurement of the heat of combustion of gases, where the gas passes through the measuring space and where it would be difficult to thermally insulate the measuring space. Another solution can be seen in a patent SU 1160294, where gases pass through the measuring chamber which is neighbouring to the compensation chamber and where the two chambers are interconnected by a heat-conducting material while the outer mantle of the meter is equipped with ribs for heat dissipation under which semiconductor thermo batteries are placed. This design is adapted for gas passage but it seems that this system combining controlled heat dissipation across thermo batteries and cooling ribs and thermal insulation of the remaining surface of the outer mantle, is rather complicated and it might be difficult to practically attain rapid and sufficiently sensitive regulation of heat dissipation. Further patents, SU 1286979, 1288567, 1390557, 1402894, 1420496, 1430849, 1430850, 1430851, 1492254 and 1492255, include attempts to compensate the above drawbacks of instruments of similar types by modifying the arrangement of the measuring and compensation chambers and by adding further heating blocks.

#### Disclosure of Invention

The drawbacks of the instruments described above are substantially reduced and precise measurement of the heating value of gases is attained by a relatively technically simple instrument when using heating value meter for gases according to the present invention that consists of an outer mantle with thermostatically controlled heating and at least one inlet for air and for the test gas, and of a measuring block located inside the outer mantle, where the principle of the meter lies in the fact that the outer mantle is cylindrical and provided with a heating mantle on its outside surface, and that its bottom part contains an axially

placed outer sensor of an electrical long-distance thermometer of the outer thermostatic apparatus, and, simultaneously, the measuring block is cylindrical, with an axially placed through-hole, is placed coaxially inside the outer mantle and is provided in the upper part with an axially-inserted internal sensor of an electrical

5 long-distance thermometer of the internal thermostatic apparatus, while the heating mantle and the outer sensor and the electrical heating block and the internal sensor are simultaneously interconnected across the thermostatic apparatus adjusted for maintaining a constant temperature by regulating the input of the electrical heating block or of the input of the heating mantle where a meter

10 of the electric input is also connected. It could be advantageous when both the outer mantle and the measuring block of the meter of the heat of combustion of gases are made of a metallic material, with especial advantage of an alloy based on copper or aluminium. It is also advantageous when there is a gap between the outer surface of the measuring block and the internal surface of the outer mantle,

15 with a width equal to 0.3 to 3.0 fold the outer diameter of the measuring block. It is also an advantage if the overall cross-section of the outlets of the flue gases equals 1.1 to 2.0 fold the overall cross-section of the air inlets. It is further advantageous if there are at least two air inlets in the outer mantle and if they are directed at an angle and/or are diverging from the longitudinal axis of the

20 measuring block. It is advantageous, too, if the electrical heating block and/or the internal sensor are placed closer to the circumference of the measuring block than to its axial through-hole. It is also advantageous if a cavity is created or a shielding body made of a thermally insulating material placed between the electrical heating block and/or the internal sensor, and the axial through-hole.

25 Finally, it may be advantageous if the internal thermostatic apparatus is adjusted for regulation of the electrical input to the electrical heating block within a range from 5 to 50% of the heating capacity of the calibration gas combusted in the meter. Another principle underlying the invention is the mode of operation of the meter that involves first a calibration stage consisting of feeding the a calibration

30 gas with an exactly known heating capacity to the meter and of its combustion,

followed by measurement of the temperature of the internal sensor and storage of the value in the memory of the measuring apparatus, and subsequently a measuring stage in which the test gas is introduced into the meter and combusted while the measuring apparatus measures the electrical input to the electrical heating block, the internal thermostatic apparatus maintains the measuring block temperature, measured at the internal sensor, at the same values as those obtained and stored in the memory during the calibration stage, and the value of the heat of combustion of the test gas is determined from the difference between the value of the heating capacity of the calibration gas and that of the electrical heating block, maintaining the temperature of the outer mantle at the same and constant value during the calibration and measuring stage. It is favourable to repeat the calibration stage every 30 to 300 minutes.

In this way a meter is obtained that is relatively simple and still reliably measures the heat of combustion of gases with a common precision of around 1%, or even better.

#### Brief Description of Drawings

Below, the invention is more closely explained and described on a preferred embodiment, with reference to the accompanying drawings in which Fig. 1 is the vertical cross-section through the measuring instrument and Fig. 2 is the scheme of the connection of the measuring instrument in the measuring system, with a connection to the pipeline transporting the test gas.

#### Modes for Carrying out the Invention

The meter 1 consists of the outer mantle 10 provided with the heating mantle 101, here designed as an electrical resistor heating mantle, with the

measuring chamber 11 placed inside the outer mantle 10. The outer mantle 10 is an aluminium cup-shaped case closed with a lid at the bottom. The bottom lid contains the inlets 103 for air and the test or calibration gas. The present example has two inlets 103 for air, perpendicular to the lid plane and between them, in the middle of the lid, is the inlet 105 for the test or calibration gas, which is parallel with the air inlets 103. The outer temperature sensor 102 is placed axially at the bottom edge of the cup-shaped case. The outer temperature sensor 102 is connected to the outer thermostatic apparatus 2 which is further connected to the heating mantle 101. The outer thermostatic apparatus 2 also contains an energy source, or can be connected to an external energy source which is not depicted here. The centre of the upper part of the outer mantle 10 contains the outlet 104 for the flue gases, the ratio between the cross-section of the outlet 104 and the overall cross-section of the air inlets 103 being 1.3, while the gap between the outer surface of the measuring block 11 and the internal surface of the mantle 10 equals the outer diameter of the measuring block 11. The measuring block 11 is designed as a hollow cylinder made of aluminium, where the axial hole 113 in the measuring block has a diameter corresponding to that of the outlet 104 for the flue gases and is directed at the top toward the outlet 104. In the axial direction, close to the axially directed hole 113, the thermally insulating holes 114 are made in the bottom and top planes of the measuring block 11, while the hole containing the internal temperature sensor 112 is made in the bottom plane in the same direction but closer to the outer circumference of the measuring block 11 and the hole containing the electrical heating block 111 is made in the upper plane. The internal temperature sensor 112 is interconnected with the internal thermostatic apparatus 3 that is further connected, via the measuring apparatus 31 of the electrical input, to the electrical heating block 111. The measuring apparatus 31 is then connected to the evaluating and control unit 4 that is based on a computer and is simultaneously connected to the first dosing unit 41 for the calibration gas and the second dosing unit 42 for the test gas.

The equipment according to the invention operates as follows. First, the calibration stage takes place, i.e., the calibration gas with a precisely known heating capacity, or heating value, is introduced into the meter 1 and is combusted in it, followed by measurement of the temperature at the internal sensor 112 and the storage of the value in the memory of the measuring apparatus, and then the measuring stage takes place, involving introduction of the test gas into the meter 1, its combustion in the meter, with measurement of the electrical input to the electrical heating block 111 by the measuring apparatus and simultaneous maintaining, by the thermostatic apparatus 3, of the temperature of the measuring block 11 measured at the internal sensor 112 at the same value as that determined and stored in the memory during the calibration stage; the value of the heat of combustion of the test gas is then determined from the difference between the value of the heating capacity of the calibration gas and that of the heating capacity of the electrical heating block, while the temperature of the outer mantle 10 is maintained at the same and constant value, by means of temperature measurement using the outer sensor 102 and subsequent regulation of the heating capacity of the electrical heating block 111, with regulation by the outer thermostatic apparatus 2. The calibration stage is repeated every 30 minutes during the measuring process, while 6 measurements of the heat of combustion value of the test gas are carried out per hour which, in view of the present requirements, can be considered to be continuous measurement. The equipment described above permitted measurements with a precision characterized by deviations not exceeding 1% from the precise value of the heating value verified by laboratory measurements and by control with other calibration gases.

In view of the computer control and monitoring of the measuring process, there is no problem in creating, basically by software means, the so-called thermal fuse which normally closes the gas inlet to heating systems when the gas supply is interrupted, to prevent explosion or pollution by non-ignited gas on resuming the supply. Here an error and alarm signal is generated when the control unit 4



records that the heating capacity of the compensation electrical heating block 111 no longer suffices for the compensation of the decreasing heating capacity of the test gas in the measuring block 11, i.e., that the combustion in the measuring block 11 was actually interrupted. The inlet of gases is then closed and the instrument requires intervention by the personnel.

As far as continuity of measurement is concerned, measurement can be considered continuous, except for the calibration stages. However, these interruptions do not prevent calling the measurement continuous, as the present-day criteria for continuous measurement require that at least 6 measurements be performed per hour. The equipment described here permits at least 6 measurements per hour without any problem, with a calibration frequency of up to every 30 minutes, including the periods of time required for temperature establishment and stabilization in the measuring apparatus 1, after the calibration stages.

#### Industrial Applicability

The equipment according to the invention can be used for any measurement of the heating value of combustible gases, however, it is especially suitable for continuous, fully automated measurements of the heating value of natural gas and of similar heating gases for which such measurement is required according to the present invoicing regulations. Understandably, the equipment is equally readily applicable to both the substances in the gaseous state that are designated as gases and those designated as vapours.

### Claims

1. The heating value meter for gases, consisting of an outer mantle with  
5 thermostatically controlled heating and with at least one inlet for air and the test  
gas, and a measuring block placed inside the outer mantle, characterized  
in, that outer mantle (10) is cylindrical, it is equipped with a heating mantle on its  
outer surface (101) and its bottom part contains an outer sensor (102) of an  
electrical long-distance thermometer of the outer thermostatic apparatus (2)  
10 placed axially in the wall, and a measuring block (11) is also cylindrical with an  
axial through-hole (113), it is located coaxially inside the outer mantle (10) and its  
upper part is equipped with an axially inserted internal sensor (112) of an  
electrical long-distance thermometer of the internal thermostatic apparatus (3),  
while the heating mantle (101) and the outer sensor (102), and also the electrical  
15 heating block (111) and the internal sensor (112), are interconnected via the  
thermostatic apparatus (2, 3), adjusted for maintaining of a constant temperature  
value by regulation of the input to the electrical heating block (111), or of the input  
to the heating mantle (101) where, in addition, the measuring apparatus (31) of  
the electrical input is connected to the electric lead to the electrical heating block  
20 (111).

2. The heating value meter for gases, according to claim 1,  
characterized in, that the outer mantle (10) and the measuring block  
(11) are made from a metallic material.

25

3. The heating value meter for gases, according to claims 1 and 2  
characterized in, that the outer mantle (10) and the measuring block  
(11) are made from an alloy based on copper or aluminium.

4. The heating value meter for gases, according to claims 1 to 3, characterized in, that a gap exists between the outer surface of the measuring block (11) and the internal surface of the outer mantle (10), with a width equal to 0.3 to 3.0fold the outer diameter of the measuring block (11).
5. The heating value meter for gases, according to claims 1 to 4, characterized in, that the overall cross-section of the outlets (104) for the flue gases equals 1.1 to 2.0fold the overall cross-section of the air inlet (103).
- 10 6. The heating value meter for gases, according to claims 1 to 5, characterized in, that there are at least two air inlets (103) in the outer mantle (10) and that they are bored at an angle or are diverging from the longitudinal axis of the measuring block (11).
- 15 7. The heating value meter for gases, according to claims 1 to 6, characterized in, that the electrical heating block (111) and/or the internal sensor (112) are placed in the measuring block (11) closer to its circumference than to its axial through-hole (113).
- 20 8. The heating value meter for gases, according to claims 1 to 7, characterized in, that a cavity (114) is formed between the position of the electrical heating block (111) and/or the internal sensor (112), and the axial through-hole (113), and/or a shielding body (115) made of a thermally insulating matter is placed in the cavity position.
- 25 9. The heating value meter for gases, according to claims 1 to 8, characterized in, that the internal thermostatic apparatus (3) is adapted for regulation of the electrical input to the electrical heating block (111), within a range from 5 to 50% of the heating capacity of the calibration gas
- 30 combusted in the meter (1).

10. The method of operation of the heating value meter constructed according to claims 1 to 9, characterized in, that first the calibration stage takes place involving introduction and combustion of a calibration gas with a precisely known heat of combustion in the meter (1), followed by measuring the temperature value at the internal sensor (112) and storing it in the memory of the measuring apparatus, followed by the measuring stage consisting of introduction and combustion of the test gas in the meter (1), with simultaneous measurement, by means of the measuring apparatus (31), of the electrical input to the electrical heating block (111) and maintaining, by means of the internal thermostatic apparatus (3), the temperature of the measuring block (11) measured at the internal sensor (112), at the same value as that determined and stored in the memory during the calibration stage, and the value of the heat of combustion of the test gas is determined from the difference between the heat of combustion value of the calibration gas and the value of the heating capacity of the electrical heating block (111), keeping the outer mantle (10) temperature at the same and constant value during the calibration and measuring stages.

11. The method of operation, according to claim 10, characterized in, that the calibration stage is repeated every 30 to 300 minutes during the measuring process.

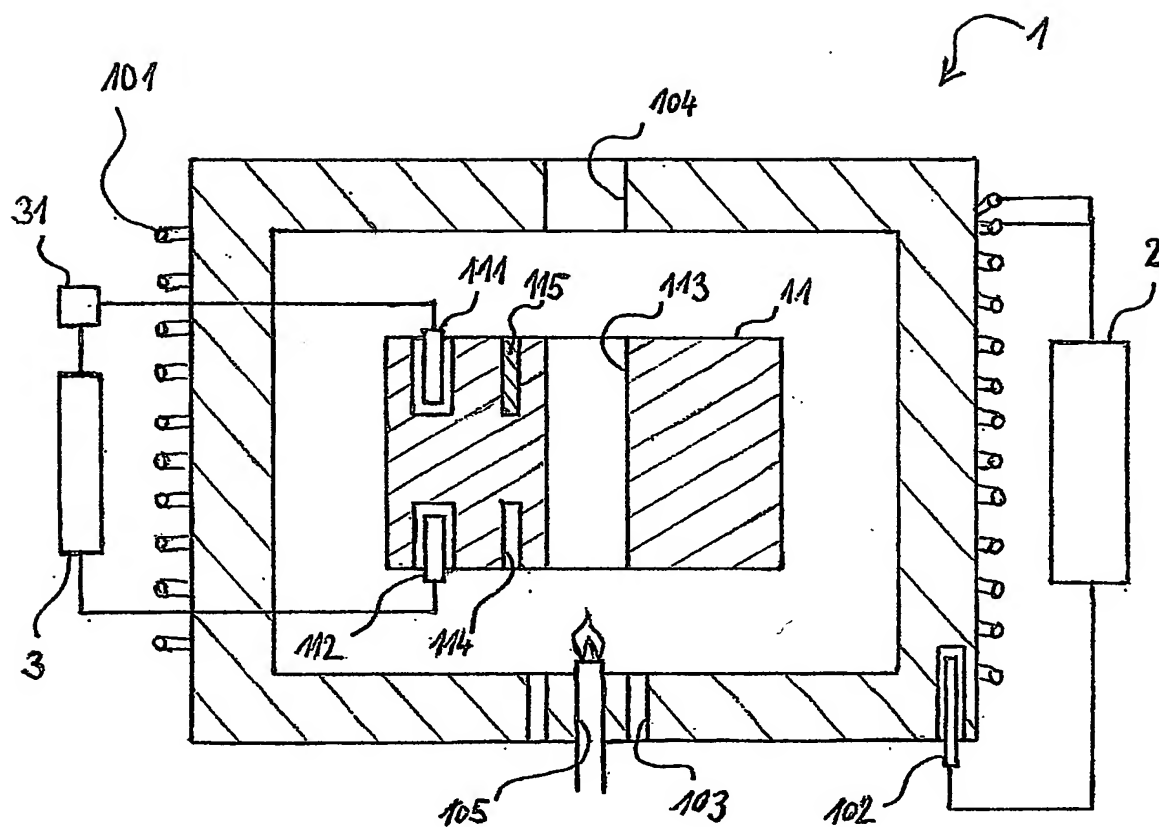


Fig.1

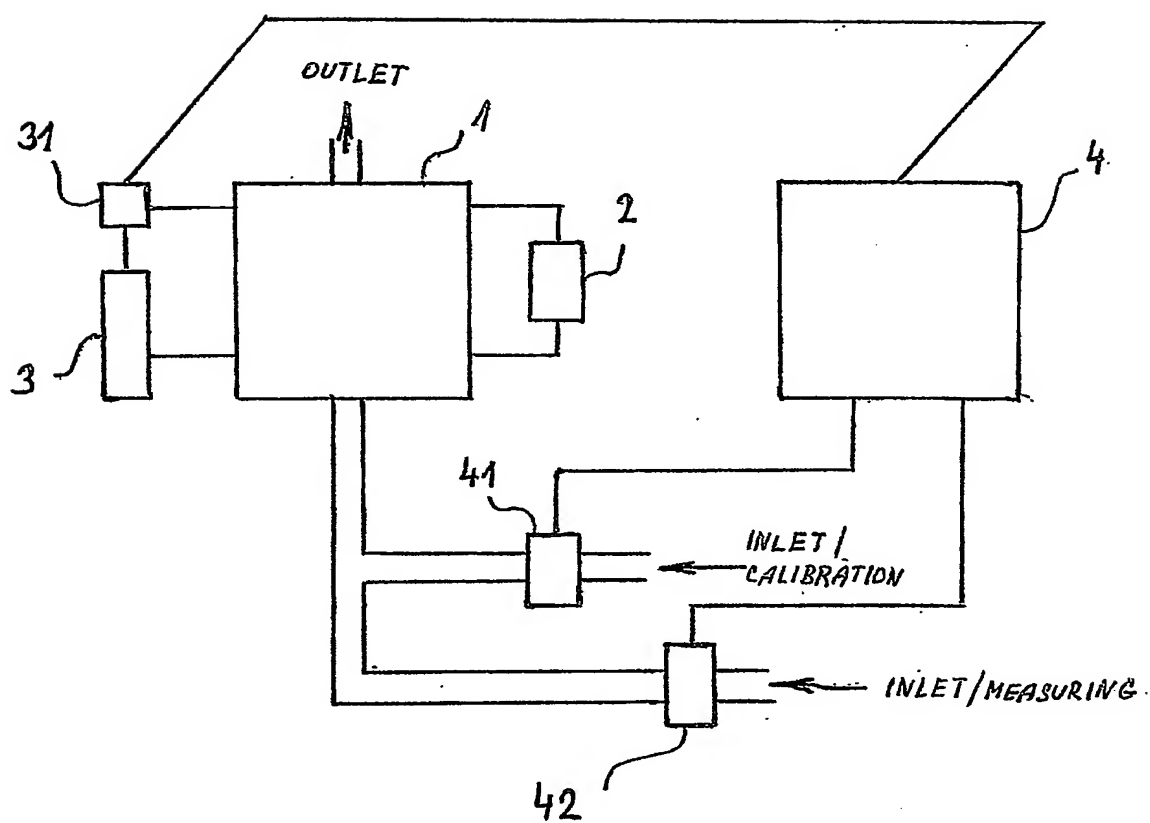


Fig. 2

## INTERNATIONAL SEARCH REPORT

International Application No.

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## A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 G01N25/20 G01N25/22 G01N25/28 G01N25/36

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 G01N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4 386 858 A (KUDE WILLIAM B ET AL) 7 June 1983 (1983-06-07) the whole document	1, 10
A	US 4 178 800 A (THOMANN CHRISTOPH) 18 December 1979 (1979-12-18) cited in the application the whole document	1, 10
A	DATABASE WPI Section EI, Week 198737 Derwent Publications Ltd., London, GB; Class S03, AN 1987-262526 XP002273014 & SU 1 286 979 A (LENGD REFRIG IND IN), 30 January 1987 (1987-01-30) cited in the application abstract	1, 10

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☒ Further documents are listed in the continuation of box C.☒ Patent family members are listed in annex.

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## INTERNATIONAL SEARCH REPORT

International Application No.

PCT/03/00065

## C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	<p>DATABASE WPI Section EI, Week 198916 Derwent Publications Ltd., London, GB; Class S03, AN 1989-121202 XP002273015 &amp; SU 1 430 849 A (LENGD REFRIG IND), 15 October 1988 (1988-10-15) cited in the application abstract</p> <p>----</p>	1,10
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Information on patent family members

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